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OXYGEN IMPURITY AND MICROALLOYING EFFECT IN A Zr-BASED BULK METALLIC GLASS ALLOY

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The thermal stability and the glass forming ability of Zr-based bulk metallic glasses (BMGs) can be dramatically reduced by oxygen impurity; consequently, high-purity charge materials have to be used for alloy preparation. In this study, a Zr-based alloy, Zr-10Al-5Ti-17.8Cu-14.6Ni (at.%), was selected as a model material, where a group of microalloying elements was selected to add to the base composition. Among the alloying elements, we have found that Pb, Si and B are most effective in alleviating the harmful effect of oxygen impurity. The beneficial effect comes from the reaction of these elements with oxygen and the formation of innocuous second-phase particles. As a result, impure Zr-10Al-5Ti-17.8Cu-14.6Ni alloy, which was completely embrittled by oxygen, can be ductilized by the microalloying process. Our studies have demonstrated the feasibility of reducing the manufacturing cost of BMGs by the use of impure charging materials. Microanalytic tools, including atom probe, have been used to characterize the structure and composition of these oxygen-rich particles, and the results will be discussed in the paper.

CAST STRUCTURE AND MECHANICAL PROPERTIES OF Zr-Cu-Al BULK AMORPHOUS ALLOYS

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Cast structures of Zr-Cu-Al bulk amorphous alloys are not usually amorphous single phase, because the cooling rates at several part of the bulk amorphous alloy are not equivalent. The morphology and sort of crystalline inclusion, which is formed during the cast process, affect on the mechanical properties of the Zr-Cu-Al bulk amorphous alloys. In order to estimate the cast structure of Zr-Cu-Al bulk amorphous alloys, liquidus surface and isothermal sections were examined. Consequently, dendritic brittle crystalline inclusions of t3-phase ($Zr_5Cu_3Al_2$) are formed in Al- and Zr-enriched area from the ternary eutectic point of $Zr_{50}Cu_{40}Al_{10}$. The formation of t3-crystalline inclusions in bulk amorphous alloy occurs significant decrease of fatigue strength and Charpy impact value. On the other hand, oxygen embrittlement of Zr-based bulk amorphous alloy is an important problem to settle for practical use of industrial materials. We found out adding 10 at% Ni element brings about a power of resistance to oxygen embrittlement. The relationship between constitutional diagram and mechanical properties was examined of Zr-Cu-Al-Ni bulk amorphous alloys. So, we conclude that the $Zr_{50}Cu_{30}Ni_{10}Al_{10}$ bulk amorphous alloy has a power of resistance to oxygen embrittlement and good ductility of Zr-Cu-Ni-Al quaternary system.

CHANGES IN THE STRUCTURE AND THE MECHANICAL PROPERTIES OF A Zr55Cu30Al10Ni5 BULK METALLIC GLASS AFTER HEAT-TREATMENTS IN THE RT-550°C RANGE

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The development of bulk metallic glasses since the early1990's has led to materials with original mechanical properties combined with batch dimensions suitable for industrial use. However, it still remains difficult to get homogeneous amorphous phase parts.

In this study, attention is focused on two main issues: The first one is to characterise the structure of a $Zr_{55}Cu_{30}Al_{10}Ni_5$ bulk metallic alloy at room temperature (as-cast) and after heat-treatments between 400 and 550° C. The second one is to study the mechanical properties at room temperature, after the same heat-treatments. At room temperature, dendritic crystallised phases, not yet identified, were observed by X-ray diffraction and by optical and scanning microscopy. The size of the dendrites ranges from 40 mm (surface) and 150 mm (core). An EDS analysis reveals an Al-rich and a Ni-poor phase compared to the glassy matrix. A heat-treatment at 550°C ends with the formation of oxides (2 micrometers thick passive surface layer) and crystals in the bulk (Zr_2Cu and $AlCu_2Zr$), while cyclic heat-treatments from 400 to 540°C develop different crystallised phases than the ones after the heat-treatment at 550° C. The mechanical properties (elasticity, hardness) were subsequently investigated at room temperature.

INFLUENCE OF WATER VAPOR ON THE FATIGUE BEHAVIOR OF A ZIRCONIUM-BASED BULK AMORPHOUS ALLOY

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Exciting recent advances have led to the development of bulk amorphous materials (BAMs) with fabrication diameters as large as 20 mm. Although the mechanical behavior of BAMs has been studied. The fatigue characteristics in the absence of water vapor, i.e., in vacuum, have not been evaluated. Early fatigue studies have resulted in fatigue strengths lower than anticipated. It is suspected that environmental effects degrade the fatigue life. Fatigue testing of a zirconium-based bulk amorphous alloy glass has been performed in a 3.5 % NaCl (weight percent) electrolyte at room temperature. Results of these tests indicated a substantial decrease in fatigue lifetimes when compared with those conducted in air. The next step toward understanding the corrosion-fatigue phenomenon is to compare fatigue results in air and vacuum. This comparison will define any detrimental effects of humidity on fatigue lifetime. Amorphous samples of BAA-11, Zr-10Al-5Ti-17.9Cu-14.6Ni (atomic percent), prepared by arc melting and drop casting, were machined into 32 mm long test specimens. The samples were then subjected to cyclic loading under varying stress levels and frequencies. The test results yielded number of cycles to failure over a broad stress range for both air and vacuum environments, and elucidated the effects of water vapor and frequency on the corrosion-fatigue phenomenon.